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THE PLETHYSMOGRAPHIC EVIDENCE FOR THE TRIDIMENSIONAL THEORY OF FEELING.¹

By H. C. STEVENS.

The controversy which, at present, exists in Experimental Psychology, between the adherents of the pleasantness—unpleasantness² theory of feeling and those of the tridimensional theory, needs a recapitulation of its arguments *pro* and *contra*. In 1896, Wundt published the tridimensional theory of feeling in the *Grundriss der Psychologie*; another exposition was published in the *Vorlesungen*, 3rd ed., 1897. In 1899 Titchener³ published a criticism of Wundt's theory. This, Wundt⁴ replied to at some length, in the same year. In the introduction to his article, Titchener points out that in the absence of experimental results which bear on the discussion, his arguments are based on introspection and general reasoning. But since the lack of experimental results affects Wundt as well, then, by inference, his theory rests on the same foundation as Titchener's arguments. The experiments of O. Vogt might seem to support the Wundtian theory; they are, however, not admissible since (1) the results do not agree with Wundt's; (2) the method of experimentation has not been confirmed. There are two specific objections to the tridimensional theory and some negative observations.

(1) Since feelings are limited by maximal contrasts, no pairs of feelings would be true feelings unless they exhibited this peculiarity. E—D and S—R do not; D is or may be merely the absence of E; R is or may be merely the absence of S. Neither D nor R is a truly active feeling, and therefore cannot be the maximal opposite of E and S. (2) Wundt gives two different accounts of the way in which the chief directions of feeling are related to other mental processes. (a) In the *Vorlesungen*, P—U correspond to the qualitative aspect of sensation; E—D, to the intensive aspect; and S—R, to the temporal aspect.

¹From the Psychological Seminary of Cornell University.

²Throughout this article, I shall indicate respectively Pleasantness-Unpleasantness, Excitement-Depression, and Strain-Relaxation by the letters P—U, E—D, and S—R.

³Zur Kritik der Wundt'schen Gefühlslehre. *Zeitschrift für Psych.*, 19, 321.

⁴Bemerkungen zur Theorie der Gefühle. *Phil. Stud.*, 15, 149.

Now, if quality, intensity and duration are represented in the directions of feeling, ought not our spatial experience also to have a direction of feeling, *e. g.*, expansion and contraction? (b) In the *Grundriss*, there is a different explanation of the relations. If a feeling modifies a present state of consciousness, it is P—U; if the feeling exerts a definite influence on a future state, it is E—D; if the feeling is determined in its peculiarity by a past state it is S—R. In the former case, the directions of feeling depend on the attributes of sensation; in the latter, on the temporal course of consciousness. (3) The third point consists of some introspective observations. A practised student observed his affective experiences during the year; the result was that no emotive content, besides P—U, was observed which could not be definitely localized in a bodily organ.

Wundt replies to this criticism in detail. He first considers the statement that no experimental results were extant prior to the publication of his theory. He indicates several sources of such results. (a) He himself had pointed out, in the 4th edition of the *Grundzüge*, that P—U are mainly dependent on the common feelings; that, in the case of tones and colors, such terms as 'stimulating' and 'mild,' 'exciting' and 'depressing' are necessary to describe the attendant feelings. (b) There were also Mosso's older experiments with the balancing board and hydrosphygmograph, as well as those of Kiesow and Mentz with taste and acoustic stimulation. (c) In the present paper, Wundt finds corroboration of his theory in Lehmann's *Atlas of Plethysmographic Curves*. We shall return to this point later. (d) Wundt also returns to O. Vogt's results. This may be due to the opportunity which Wundt had had of seeing the method in use, during a visit of Vogt to Leipzig. The results are in essential agreement with his own. Vogt has a *hebende* and a depressing feeling, and S—R. There are, however, two differences. (i) Vogt has a feeling of activity (*Activitätsgefühl*) which is concomitant with the activity of the will. (ii) The types of feeling are not merely directions of feeling, but are themselves simple, indivisible feelings. In accounting for these differences, Wundt identifies the feeling of activity with E, probably in combination with S—R. The second point of difference, he thinks, is due to the small compass of stimulus effects that Vogt observed.

(1) To the first objection, that D—R are not active feelings and therefore not the maximal opposites of E and S, Wundt answers that they are *facts*, determined by introspection. (2) a. Spatiality is not one of the feeling directions, because it does not appear either in introspection or in expressive movements. b. As to the two references of the feeling directions, they are merely two ways of viewing feelings in relation to other mental

processes. On the one hand, feelings are related to the attributes of the sensation; on the other hand, they are related to its temporal course. These two relations are not mutually exclusive. (3) Wundt criticises the introspective observations, *a.* because introspection was used without experimental control, and *b.* because the statement of the result—that besides P—U, no other emotive content was found which could not be definitely localized in a bodily organ and was therefore a sensation or sensation complex—implies that feeling does not depend upon sensation. But this is not true.

So far, our purpose has been to summarize the arguments and replies of the two protagonists in the discussion, with a view to bringing out the state in which the question at issue now rests. The more immediate end of this essay, however, is to test the validity of the interpretation placed by Wundt upon certain of Lehmann's curves.

Up to 1899, the most complete and available experimental material for the study of feeling was afforded by Lehmann's¹ Atlas of Plethysmographic Curves. As already mentioned, Wundt² found substantial support for his theory in these curves; and, indeed, with the possible exception of Mentz' work, this was the first considerable experimental investigation of the problem of feeling. It is necessary to distinguish, in these curves, two distinct types of reactions. On the one hand, there are the simple, unequivocal reactions of P—U; on the other, there are complications of reactions, which are considerably involved. Wundt is concerned mainly with the latter, and, in his interpretations of them, differs radically from Lehmann. Lehmann thinks that the "resultant" curves are complications of P—U effects with strain-states (*Spannungszustände*) of the attention; the strain-states he believes to be sensation processes only, without any feeling character whatever. Wundt takes an opposite view. He says: "I do not, however, consider as such components, P—U on the one hand, and other states of consciousness not affective in character, on the other; but feeling components of different quality and expression, throughout."³ Wundt's procedure, then, in turning the resultant curves to account for his own theory, consists in finding curves, the pulse-characteristics of which agree with the

¹Leipzig, 1899.

²It should be pointed out that Wundt's draftsman has reproduced but poorly the curves of Lehmann's atlas. For example, Fig. 3 is 2 mm. shorter than the corresponding part of Lehmann's curve; and Fig. 1 is 1.5 mm. shorter; also, the reproductions of many individual pulses are grotesque.

³*Loc. cit.*, p. 157.

logically determined pulse-characteristics of the chief directions of feeling. Thus, the pulse of P, E and R is intensified; but P retards the rate; E does not change it; R accelerates it. Similarly, S, D and U weaken the pulse; while S retards the rate; D makes no change; U accelerates. Now, the purpose of this essay is to inquire how far the physical characteristics of the curves bear out the constructions that are put upon them; and that on the basis of Wundt's own pulse determinations.

Wundt quickly passes over curves of P—U. These reactions are well known. He finds, however, two plates, XXII and XXIII, which show the expressions of E—D unmixed, at least, with P—U. These plates give the results of experiments with a state of feeling which Lehmann was, at first, unable to explain. The observer P. L., "a strongly built grown man," gave a curve of small constant volume and small pulse. This reaction, Lehmann suspected, was not normal. After several attempts, it was evident that the state was proof against ammonia stimulation and the fright caused by a sudden noise, XXI B. C. It yielded, however, on another trial, XXI D., a small increase in volume to fright (contrary to the normal reaction), and a marked reaction to P, which was exceptional. These were the circumstances under which plates XXI, XXII and XXIII were obtained. That is, an abnormal state was present, the symptoms of which were constantly diminished arm-volume and small pulse.

After failing with more severe stimuli, Lehmann attempted to dissolve this state with "weak, pleasant and sufficiently varied stimuli," such as could not set up a psychical strain (*Spannung*.) He began, XXII A, with "some weak tuning fork tones." Two stimulations were given: (i) short; this yielded a plain increase in arm-volume; (ii) long: this yielded an equally plain decrease. The next three curves, however, B, C, D, showed certain common variations. At the very beginning of the curves, the arm-volume was large and the pulse high. Very soon the volume sank to a low level with small pulse. In XXII E, Lehmann touched the observer very softly on the ear; this was pleasant; a little later the volume increased, and maintained itself at a high level with large pulse. This reaction gave Lehmann the key to the explanation. He says:¹ "I now feel tolerably certain of my case; the relatively large volumes, with high pulse, were the indication of the normal balance of affection in which the observer happened to be when he did not expect a new experiment; but as soon as an experiment impended, the psychical strain (*Spannung*) returned, characterized by small arm-volume and low pulse. If

¹ *Die körperlichen Aeusserungen psychischer Zustände*, p. 81.

this be the correct view, then one would need only to wait a moment for the strain to cease, and the reaction would become normal again." Plate XXIII furnishes proof of the correctness of this hypothesis. In A, the stimulus was a loud noise, which produced some fright. The fright expressed itself by a small decrease in volume; after this, there was a distinct increase in volume above the original *niveau*, with increasingly larger pulse. Similar changes took place in the three other curves. With reference to this set of experiments, XXI—XXIII, Lehmann says:¹ "The main fact that emerges out of all these experiments with irregular results is, that the observer was only rarely in a normal balance of affection; while another state of feeling dominated throughout. That this foreign state was strain or expectation is not however completely proved; it is only a provisional hypothesis, if, at the same time, a very natural one." He says, further, that sure proof would be furnished, if a state of strain (subjectively certified to) could be induced, the symptoms of which were identical with the curves just noticed. Such curves are XXIV A, C, D. This evidence Lehmann considers conclusive, and in the light of these results he finds many other examples of strain in other observers. For example, XXV A, B, C, D.

Wundt calls these reactions relatively pure expressions of E. The symptoms of this state are a "sudden increase of arm-volume and of pulse intensity, without further noticeable change in the temporal course of the pulse."² The only curves in plates XXII and XXIII which answer this description, in part, are B, C, D, E XXII; A, B, C, D XXIII. The reactions in these curves agree with the two positive characteristics of E, *viz.*, the increase in arm-volume and the intensification of pulse. But these symptoms apply equally well to P and R. Also, the sudden rise is not discriminating, since the rise is by no means sudden in all cases; *e. g.*, XXII C, E and XXIII A, C. The *differentia*, therefore, of P, E, and R must depend on some other change in the pulse than intensification. According to Wundt's schema, this *differentia* will be temporal: retardation for P; constancy for E; and acceleration for R. These temporal changes may be accurately determined by comparing the average length of pulse in the first part of the reaction with the average length of pulse in the last part. The result of the measurements is given in the following Table:

No. of Pulses	Average Length Lower Half	Average Length Upper Half	Curve	Stimulus
3	4.3	5.6	XXII B	Initial Rise
5	4.4	5.0	" C	After Stim.
9.5	4.0	5.2	" E	" "
4.5	4.4	5.4	XXIII A	After Fright
3.5	4.2	6.4	" B	" Stim.
4.0	6.7	6.3	" C	" "
				Tuning fork.

¹ Lehmann: *ibid.*, p. 83.

² Wundt: *ibid.*, p. 156.

With but a single exception, the average length of pulse in the upper half of the reaction shows a decided lengthening—and therefore retardation—over that in the lower half. The reactions can, therefore, hardly stand for E, as Wundt says they do; on the basis of his own *differentiæ* they stand for P.

Wundt next considers the "resultant" curves. Of these, he says, "Lehmann has also pointed out these complications in many places in his work. But even alone, they force themselves upon one by a study of the pulse symptoms, on the one hand, and of the subjective facts, on the other."¹ In support of this statement Wundt indicates an example of each. The subjective report is the phrase '*überraschender angenehmer Geruch* of patschouli.' Wundt says of this: "I think that one may, without further evidence, read out of these words, in which the author characterized the psychical impression, the combination of E and P."²

It may be true, on the subjective side, that E is present; but there is little evidence for it in the physiological expression of the curve itself, XLIV C. The reaction exhibits the sudden rise in volume and intensified pulse that characterize P, E and R. The *differentia* in favor of E is constancy of pulse during the reaction. If we resort to the previous test, the measurement of the lower half of the reaction gives an average length of pulse of 4.8 mm., against an average of 5.1 mm. for the upper half. With reference to the evidence from the pulse symptoms Wundt says: "Since the pulse symptoms of P and E are very similar to each other, except for the very plain retardation of pulse in the case of P, in this curve XLV, A, at least, the combined effects are different in the highest degree, so that with a definite increase of pulse intensity and arm-volume there is observed rather an acceleration of pulse than retardation."³ The symptoms of this curve are sudden increase in volume, constant height and acceleration of pulse. Altogether, it is an anomalous reaction. It is neither P nor U; and the place for it in the tridimensional theory is unsatisfactory. These symptoms call for R. But R could not be present, unless its co-ordinate state, S, preceded. The initial curve, however, is normal; S may therefore be ruled out, and consequently R.

Thus far, Wundt has made three attempts to demonstrate E. First, with the pure curves of E; then, on the basis of introspective evidence; finally, in complication with P. He makes another attempt on the basis of a complication with U. The three plates which Lehmann exhibits as examples of the phy-

¹ Wundt: *ibid.*, p. 156, 157.

² Wundt: *ibid.*, 156, 157.

³ Wundt: *ibid.*, p. 157.

siological expressions of voluntary attention, Wundt construes as mixtures of E and U. The stimuli in these experiments are problems in multiplication. Wundt appeals to ordinary experience for proof of the uneasiness combined with U which arises from mental reckoning. E supposedly comes from mental activity, although nothing is said about that. These curves, and they are remarkably uniform, are characterized by Lehmann as follows: "A concentration of attention (thought) is immediately accompanied by a few rapid pulses, during which the volume shows a tendency to rise. Thereupon follow 4 to 8 pulses, during which the volume shows a tendency to sink; the length of these pulses is always greater than that of those immediately preceding, often even surpassing the norm. Finally, the volume rises with rapid pulse."¹ From this description, it is evident that it will be very difficult, on either theory, to explain the reactions as affective reactions. The symptoms of P—U are just the opposite of these reactions, *viz.*, rising arm-volume and retarded pulse, for P; and sinking volume and accelerated pulse for U. It is true that the tridimensional theory has affective states which correspond with these symptoms; but they are hardly intelligible in this connection. For example, rise in volume and accelerated pulse call for R, in Wundt's schema; while fall in volume and retarded pulse call for S. Since, however, these states are co-ordinate, the presence of the one presupposes that of the other; but not in reversed order, as in this case. S must precede R, as E must precede D. Therefore in this case R could not precede S, unless another S had preceded R. But there is no evidence for this, as the initial curve is normal in every respect.

Wundt seems curiously in error with regard to these curves. He describes them as follows:² "They show, as a rule, the decrease in arm-volume characteristic of U and occasionally, also, acceleration of pulse; but acceleration of pulse occurs with an increase in arm-volume, not with a diminution. Frequently, also, these different symptoms succeed each other; first, the arm-volume sinks with an increasing pulse rate; then, it rises, in accordance with the growing uneasiness which is wrought by the difficulty of mental reckoning." These statements, so far as they are intended to apply to plates XV, XVI, XVII, are inaccurate. The arm-volume never falls first; it rises, or tends to rise.

The demonstration of S—R is also attempted. The symptoms of these states (*Spannungszustände*) are described by

¹Lehmann: *ibid.*, p. 68.

²Wundt: *ibid.*, p. 157.

Lehmann as "continuously diminishing arm-volume with lessened intensity of pulse."¹ Wundt, however, sees in some of the curves still another symptom which he describes as a "retardation, therefore lengthening or at least . . . an unchanged magnitude of length of pulse."² The plates referred to as examples are XXIV and XXVI C. D. The decision of this point will depend upon the time relations of the curves themselves; and since Lehmann had already been led to consider the relation of the rate of pulse to S, we may use his measurements.

Curve	Period	Strain State	Period	Normal State.
XXII D, E.	e—f	5.2	i—m	5.1—5.2
XXII C	c—d	4.9	g—h	5.0
XXIII C	—	7.0	—	6.6
XXIV A, B	d—e	5.8—5.3	i—k	7.0
XXIV C, D	l—m	4.4	q—r	4.4

Lehmann's conclusion is this: "S does not cause a constant change in the frequency of heart rate. The length of pulse may be longer at one time, and again shorter than the norm. But it never varies greatly from it."³

Although Wundt cites plate XXVI in this connection, it need not be considered, as there is no evidence that a state of S is present.

The conclusion to this paper is, then, that Wundt's appeal to Lehmann's atlas, for evidence in support of the tridimensional theory, is unsuccessful. It is unsuccessful because (1) the examples of E do not show constancy of pulse rate during the reaction; because (2) the complication of E with P is not intelligible on the tridimensional theory; because (3) the introspective evidence of E is not borne out by the pulse characteristic of the curve; because (4) the complication of E with U is not intelligible on the tridimensional theory; and because (5) the retardation of pulse, in the case of S, is not borne out by measurements of the curves.⁴

¹ Lehmann: *ibid.*, p. 89.

² Wundt: *ibid.*, p. 158.

³ Lehmann: *ibid.*, p. 89.

⁴ As will have been apparent, the aim of this article is in no way similar to that of the recent paper by R. Müller, on the applicability of the plethysmograph to the study of the affective processes (*Z. f. Psych.*, 30, Heft 5 and 6). The purpose of Müller's article is to set forth the physiological factors involved in certain variations of blood-volume and blood-pressure, and also to criticise the adequacy of the plethysmographic method to the expression of these variations. If Müller's criticism is directed against any one person, that person is Lehmann. Our own attempt has been to show the invalidity of Wundt's interpretations of certain of Lehmann's curves, selected by him on the basis of his own *differentiae*.